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## CONTROL OF SEEDBED DISEASES OF CRUCIFEROUS CROPS ON LONG ISLAND BY THE MERCURIC CHLORIDE TREATMENT FOR CABBAGE MAGGOT

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BULLETIN NO. 537

# CONTROL OF SEEDBED DISEASES OF CRUCIFEROUS CROPS ON LONG ISLAND BY THE MERCURIC CHLORIDE TREATMENT FOR CABBAGE MAGGOT

E. E. CLAYTON

## ABSTRACT

This is a report of experiments conducted during the years 1923, 1924, and 1925 with the object of determining the disease control value of the mercuric chloride treatment for maggots when used in cabbage, cauliflower, and brussels sprouts seedbeds.

Mercuric chloride is a good disinfectant and a number of the important diseases affecting these crops, such as club-root, (*Plasmodiophora brassicae* Wor.), black-leg (*Phoma lingam* [Tode] Desmaz), black-rot or blight (*Pseudomonas campestris* [Pammel] E. F. S.), and damping-off (*Rhizoctonia solani Kuhn*), are encountered first during the seedbed period. Previous observations and experiments have indicated that the mercuric chloride treatment for maggots, when used in the seedbed, may also give partial or complete control of one or all of the above diseases. The chief object of the present work was to determine to just what extent a grower would be justified in depending on this seedbed treatment for disease control.

Long Island farmers who treat their seedbeds for maggots are accustomed to making two applications, sometimes three, and not at all infrequently but one. In these experiments the number of applications was generally two or three and the work was conducted under normal field conditions.

Club-root infection was reduced to a low minimum by applications of mercuric chloride solution. Two applications were generally quite effective, while in one experiment a single treatment given just as the plants were showing first true leaf reduced the amount of club-root from an average of 66.3 per cent in the untreated checks to 2.6 per cent in the treated plats. Mercuric chloride appeared to be equally effective in dilutions of 1 to 2,000 or stronger. Organic mercury preparations proved as effective against club-root as the mercuric chloride and possessed an added advantage in that they were much less likely to injure the plants. They have the disad-

vantage of being much inferior to mercuric chloride in controlling maggots.

Two to three seedbed treatments gave marked control of black-leg in all but one of the experiments in which the black-leg infection was seed-borne. Indeed, treatment in the seedbed with mercuric chloride gave fully as good control of the disease in these experiments as was secured with the standard mercuric chloride seed treatment. In all experiments, however, where the source of the black-leg infection was the soil and not the seed, the seedbed treatments were ineffective. This was a disappointment, since it was hoped particularly that treatments in the seedbed would give protection against soil-borne infection of this disease, for in so far as seed-borne infection is concerned the hot water seed treatment gives results far superior to those secured either by seed or seedbed treatment with mercuric chloride.

The results secured in the black-rot experiments were similar in all respects to those secured with black-leg.

Seedbed treatments as used in these experiments failed to control damping-off and it appears that under our conditions treatments would have to begin with the appearance of the plants above ground to check this disease.

Considering the results as a whole, it may be said that the disease control properties of the mercuric chloride treatment as used for cabbage maggot are very considerable in that danger from club-root is greatly reduced and that black-leg and black-rot infections carried with the seed are largely destroyed.

These qualities, in the combination with its insecticidal properties, combine to make the mercuric chloride treatment a valuable control measure in combating cruciferous crop diseases encountered during the plant-bed period.

## INTRODUCTION

The mercuric chloride treatment for the control of the cabbage root maggot has come into extensive use within the last few years. On Long Island it has met with much favor and is used regularly by many growers of cabbage, cauliflower, and brussels sprouts. These crops are chiefly grown in this locality in the late summer and fall, and hence the maggots are only a plant-bed problem.

The use of mercuric chloride as an insecticide is new, but the compound has long been known as an excellent disinfectant; consequent-

ly, when reports were received from various quarters of striking disease control following seedbed treatments applied for maggots, it appeared important to determine as exactly as possible the value of this maggot treatment as a control for some of the diseases commonly encountered in the plant beds. These diseases are club-root caused by *Plasmodiophora brassicae* Wor., black-leg caused by *Phoma lingam* (Tode) Desmaz., black-rot or blight caused by *Pseudomonas campestris* (Pammel) E. F. S., and damping-off caused by *Rhizoctonia solani* Kühn.

## EXPERIMENTAL PROCEDURE

The chief object of this work was to determine the disease control value of the mercuric chloride maggot treatment as it is used in the seedbeds on Long Island. In this locality the beds are sown during the period of maggot activity and the plants are exposed to infestation from the time they appear. Owing to the fact, however, that the very young seedlings are sensitive to injury from mercuric chloride—especially cauliflower and brussels sprouts—it has been thought unadvisable to make the first maggot treatment any earlier than necessary. The practice followed in these experiments was to give the first treatment as soon as the first true leaf was formed.

Huckett (9)[1] recommends for Long Island that cauliflower be given the first treatment when the plants are two weeks old, and in this instance age is counted from the time the seedlings appear so that this means from 17 to 20 days after seed sowing. The average period from seed sowing to first treatment in these experiments was 16.4 days which, in view of the above, is a little short, but on the other hand, it is longer than often recommended for cabbage. The average period between the first and second treatments was 8.2 days and the space between second and third treatments was about the same.

Every care was taken to apply uniformly, and at the same rate, all solutions used at any one time. Solutions were not, however, applied at the same rate thruout the seedbed period. The rate of applications for very young plants averaged 1 gallon to 40 feet of row, and this was increased as the plants grew in size to a maximum of 1 gallon to 18 or 20 feet of row. These applications were sufficient to moisten the soil for several inches on either side of the row. To

[1]Refers to Literature Cited, page 28.

facilitate penetration downward the plats were always cultivated just before treating, using a wheel hoe and working close to the rows.

The plats treated consisted of double rows from 6 to 10 feet long and each treatment was repeated from five to ten times in most experiments. The usual arrangement was four treated plats and then two untreated checks with intervals of 2½ feet between treatments. In no case was there any indication that treatments affected any plat other than the one to which they were applied. In the data which follow no mention is made of maggot control so it may be recorded here that in the experiments conducted during the springs of 1924 and 1925 moderate maggot infestations were encountered and counts of affected plants made. In all cases either two or three applications of mercuric chloride gave satisfactory control of maggots.

## CONTROL OF CLUB-ROOT BY SEEDBED TREATMENTS

Club-root, while not the most destructive disease attacking cruciferous crops on Long Island, may well be called the most bothersome. Every grower is acquainted with this disease and takes great care to avoid it. The general experience is that when cabbage, sprouts, or cauliflower are grown several years successively on the same ground, or when they are grown in too short a rotation, club-root is likely to appear. There is nothing certain about the disease, however, for soil and weather conditions greatly influence its development. The writer has seen instances where cruciferous crops have been grown three years in succession without evident development of club-root. On the other hand, it sometimes happens that the second year's crop is so badly infested as to be almost worthless. Occasionally club-root is encountered in land never before planted to cultivated crops and in these cases the infection may be attributed to certain weeds that are subject to this disease. The black mustard, a very common weed on Long Island, is one of these. Not infrequently seedbeds are located on infested ground, and when this happens the plants may be a total loss.

At present there is no really effective control for club-root. The usual three- to four-year rotation tends to keep the disease in check but does not eliminate the infection. Liming the ground has long been recommended as a preventive for club-root, but to be effective the soil reaction must be brought to the neutral point, and, since Long Island soils are naturally very acid, extremely heavy applications of lime are necessary, and quite aside from the cost there are

serious objections to this proceedure. Other soil-borne diseases are being combated by the development of resistant varieties, but up to the present no varieties of cabbage, sprouts, or cauliflower have been developed that are resistant to club-root. Consequently, any measure that promises to assist in controlling club-root is certainly worthy of investigation.

In this country the first report of successful club-root control by means of fungicidal solutions applied to the growing plants was made in 1924 by Gloyer and Glasgow (6) who obtained excellent results with mercuric chloride solutions.

In Europe the efficiency of the mercury compounds, especially chlorophenolate of mercury (Uspulun), as a preventive of club-root has been recognized somewhat longer. Thus, in 1921, Rattke (10) reported that as a result of watering cauliflower set in diseased soil twice with a 0.5 per cent solution of Uspulun the disease was reduced to a very low minimum, while untreated plants growing alongside were completely destroyed.

The limitations of the treatment have also been recognized. Thus, Bremer (1,2) and Ludwigs (8) found that the disinfectant failed to kill the resting spores of the disease-producing fungus and merely afforded a temporary protection. Ludwigs further reported a marked tendency for the disinfectant to be retained in the upper soil with the result that deep-lying roots were very liable to infection.

In continuation of these investigations experiments have been conducted with results as recorded in the following pages.

## EXPERIMENT I

On May 28, 1924, cabbage and cauliflower seed was sown in plats of three rows each 8 feet in length. The land used had produced a badly "clubbed" crop of cabbage the previous year. Mercuric chloride in dilutions of 1 to 1,800 for the first application, 1 to 1,500 for the second application, and 1 to 1,200 for the third application was compared with formalin and Semesan, both of which materials were used in 1 to 500 dilutions for all three applications.

The percentages of club-root infection secured in this experiment showed considerable variation which indicated that the distribution of the disease thru the soil was not entirely even. Of the three materials used the mercuric chloride gave the best control. Semesan appeared to give partial control, while formalin in the strengths used was without effect.

It was very encouraging to find that not only did two applications of mercuric chloride give good control, but that even a single treatment appeared to reduce materially the amount of disease.

## EXPERIMENT II

It seemed desirable now to obtain more definite information as to how strong a mercuric chloride solution was necessary for club-root control, also to determine the relative plant toxicity of different dilutions. For this purpose brussels sprouts seed was sown on August 16, 1924, in two-row plats each 10 feet long. Seventy-two plats were separated from each other by the usual 2½ foot intervals. Every third plat was reserved as an untreated check and in this way the growth of plants in each treated plat could be compared with an immediately adjacent untreated plat. The mercuric chloride was applied twice in dilutions from 1 to 1,200 to 1 to 3,000, as given in Table 1. Time did not permit the full number of plants to be counted.

TABLE 1.—AMOUNT OF CLUB-ROOT INJURY FOLLOWING TWO APPLICATIONS OF MERCURIC CHLORIDE TO THE SEEDBED.

| SERIES | PERCENTAGE OF CLUB-ROOT INJURY | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Untreated checks | Mercuric chloride dilutions | | | | | | | |
| | | 1 to 3,000 | 1 to 2,500 | 1 to 2,000 | 1 to 1,800 | 1 to 1,500 | 1 to 1,200 | 1 to 1,800 and 1 to 1,500 | 1 to 1,500 and 1 to 1,200 |
| 1 | 13.10 | 6.0 | 8.15 | 2.30 | 2.05 | 3.0 | 6.65 | 4.50 | 2.4 |
| 2 | 23.20 | 6.6 | 4.40 | 3.15 | 2.45 | 2.7 | 2.60 | 3.35 | 3.0 |
| 3 | 18.75 | —— | —— | —— | —— | —— | —— | —— | —— |
| 4 | 19.00 | —— | —— | —— | —— | —— | —— | —— | —— |
| 5 | 35.30 | —— | —— | —— | —— | —— | —— | —— | —— |
| 6 | 50.45 | —— | —— | —— | —— | —— | —— | —— | —— |
| Average | 26.63 | 6.3 | 6.27 | 2.72 | 2.25 | 2.85 | 4.62 | 3.92 | 2.7 |

From the figures in Table 1 showing the percentages of club-root, it may be seen that applications of mercuric chloride even so dilute as 1 to 3,000 greatly reduced the amount of the disease. Apparently, however, dilutions above 1 to 2,000 are not so effective as those below, These results indicate that the club-root organism is very sensitive to mercuric chloride, tho the results of Bremer's (1) investigations would indicate that the disinfectant does no more than temporarily check the activity of the parasite and that it does not destroy the infection.

## EXPERIMENT III

The experiments so far have indicated that two applications of mercuric chloride in any dilution from 1 to 1,200 to 1 to 2,000, will generally control club-root. As will be pointed out later these mercuric chloride applications often caused serious plant injury and especially was this true with brussels sprouts. Consequently, it was thought desirable to compare mercuric chloride with certain of the new mercury disinfectants that have been employed with excellent satisfaction in Europe. These materials are said to be equal to mercuric chloride as fungicides and to be far safer to use.

The materials tested in Experiment III, in addition to mercuric chloride, included Semesan, Uspulun, Bayer Compound, and Germisan. All materials were used 1 to 400 except mercuric chloride which was applied 1 to 1,800 when the plants were very small, 1 to 1,500 when the plants were medium sized, and 1 to 1,200 when the plants were large. Brussels sprouts seed was sown on April 17, 1925. Representative plats were pulled and the diseased plants counted. The results are given in Table 2.

TABLE 2.—AMOUNT OF CLUB-ROOT INJURY FOLLOWING APPLICATIONS OF VARIOUS MERCURY COMPOUNDS TO THE SEEDBED.

| SERIES | PERCENTAGE OF CLUB-ROOT INJURY | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Untreated checks | Mercuric chloride applied | | Semesan applied | | Bayer Compound applied | | Uspulun applied | | Germisan* applied | |
| | | Two times | Five times | Two times | Five times | Two times | Five times | Two times | Five times | Two times | Five times |
| 1 | 20.35 | 3.15 | 0.00 | — | — | — | — | — | — | — | — |
| 2 | 4.45 | 1.85 | 0.00 | 13.8 | 1.6 | 7.7 | 0.0 | 2.5 | 2.0 | 0.6 | 0.0 |
| 3 | 3.85 | 0.00 | 2.60 | 11.8 | 5.2 | 2.4 | 5.2 | 1.0 | 0.7 | 0.9 | 0.0 |
| 4 | 17.35 | 9.75 | 1.05 | — | — | — | — | — | — | — | — |
| 5 | 8.70 | 2.25 | 0.00 | — | — | — | — | — | — | — | — |
| Average | 10.94 | 3.4 | 0.73 | 12.8 | 3.4 | 5.0 | 2.6 | 1.75 | 0.35 | 0.75 | 0.0 |

*Five applications of Germisan killed 90 per cent of the plants.

The results tabulated in Table 2 indicate that certain of these new mercury disinfectants are at least as effective as the chloride in controlling club-root. Germisan treatments resulted in the lowest percentage of infection, but this material proved even more toxic to the plants than mercuric chloride. The plats that received the five applications of Germisan had at the conclusion of the experiment only about 10 per cent normal stand. Uspulun was highly effective

against club-root and in addition caused no plant injury. Semesan caused no plant injury, but did not give as good disease control as Uspulun. Bayer Compound gave good results in disease control and also caused no plant injury.

## EXPERIMENT IV

The results obtained in Experiment III pointed to the desirability of the organic mercury disinfectants. These materials appeared to be equal to the chloride in disease control and some were distinctly less toxic toward the plants. These points were further tested in the fall of 1925.

Seed was sown on September 9, 1925, and 32 single-row plats each 6 feet long were planted. Cauliflower, cabbage, and brussels sprouts were used as plant material. The plants were just showing their first true leaf at the time applications were made as follows: Mercuric chloride 1 to 1,500, a 0.067 per cent solution; and Uspulun 1 to 333, a 0.3 per cent solution.

TABLE 3.—AMOUNT OF CLUB-ROOT INJURY FOLLOWING APPLICATIONS OF MERCURIC CHLORIDE AND USPULUN TO THE SEEDBED.

| SEED | TREATMENT | TOTAL NUMBER OF PLANTS | DISEASED PLANTS | | HEALTHY PLANTS | |
|---|---|---|---|---|---|---|
| | | | Number | Per cent | Number | Per cent |
| Cauliflower | None | 88 | 80 | 90.9 | 8 | 9.1 |
| | None | 114 | 103 | 90.4 | 11 | 9.6 |
| | Mercuric chloride | 24 | 0 | 0.0 | 24 | 100.0 |
| | Uspulun | 97 | 0 | 0.0 | 97 | 100.0 |
| Cabbage | None | 61 | 38 | 62.1 | 23 | 37.9 |
| | None | 60 | 34 | 56.7 | 26 | 43.3 |
| | Mercuric chloride | 53 | 4 | 7.5 | 49 | 92.5 |
| | Uspulun | 59 | 0 | 0.0 | 59 | 100.0 |
| Sprouts | None | 101 | 47 | 46.5 | 51 | 53.5 |
| | None | 96 | 50 | 52.1 | 46 | 47.9 |
| | Mercuric chloride | 163 | 5 | 3.0 | 158 | 97.0 |
| | Uspulun | 211 | 16 | 7.5 | 195 | 92.5 |
| | None | 167 | 105 | 62.8 | 62 | 37.2 |
| | None | 115 | 77 | 68.9 | 38 | 31.1 |
| | Mercuric chloride | 48 | 0 | 0.0 | 48 | 100.0 |
| | Uspulun | 154 | 1 | 0.6 | 153 | 99.4 |

| | Untreated | Mercuric chloride | Uspulun |
|---|---|---|---|
| Average number plants per plat | 102.25 | 72.0 | 130.25 |
| Average percentage club-root per plat | 66.3 | 2.6 | 2.0 |

In the experiment, since it was planned to make but one treatment, the rate of application was heavier than for the normal first application. In place of 1 gallon of solution to 40 feet of plant row, 1 gallon was applied to each 30 feet of row.

The outstanding results of this experiment are summarized at the bottom of Table 3. The figures showing the average number of plants per plat bring out the fact that, while mercuric chloride reduced the number of plants almost 30 per cent as compared with untreated checks, Uspulun increased the number of plants per plat by about the same amount. These figures were not a surprise for the injury resulting from the single mercuric chloride treatment was conspicuous.

The figures on the average percentage of club-root per plat show that the mercuric chloride and Uspulun were about equally effective. The high degree of disease control resulting from the single treatment was very pleasing.

### CONCLUSIONS REGARDING SEEDBED TREATMENT FOR CLUB-ROOT CONTROL

Club-root has proved very sensitive to the action of mercury compounds. Excellent control has resulted from two applications in the seedbed, and in the last experiment, from a single application made when the plants were showing the first true leaf. One grower during the past summer has obtained similar control from a single treatment. Mercuric chloride, in strengths of 1 to 1,500 and 1 to 1,800, appears to be as effective as any material, but has the disadvantage of being more liable to injure the plants than the organic mercuries, such as Uspulun.

## EXPERIMENTS WITH BLACK-LEG

Black-leg is a very destructive disease on Long Island. There it affects sprouts and cabbage most severely and the infection may be encountered either in the seed, the seedbed soil, or in the field soil. When the source of the infection is the seed or the seedbed soil this disease often destroys from 50 to 90 per cent of the plants. If the disease is only encountered in the field soil and not during the plant-bed period, the loss will rarely be more than 5 to 10 per cent. Seed and the plant-bed soil are thus the all-important sources of black-leg infection, and growers are unlikely to suffer any considerable loss from this disease provided the plants are not exposed to infection prior to the time they are set in the field.

Before these experiments were begun there was every reason to believe that in some manner seedbed treatments with mercuric chloride were useful in combating black-leg. During the summer of 1922, certain growers who use corrosive sublimate for maggots in the plant-bed had untreated field plats that were badly affected by black-leg, while their fields set with treated plants were practically free from the disease. In Pennsylvania, Hodgkiss and Horsefall (7) report similar observations. In all these instances, however, the actual source of the disease infection, whether seed or soil, was not known. Since seed-borne infection may be readily destroyed by seed treatment it was hoped that the seedbed treatments would be found effective in preventing infection from the soil. In this way seed treatment to destroy infection in the seed and seedbed treatment to take care of any infection encountered in the soil would fit together to give 100 per cent protection.

## TESTS WITH BLACK-LEG INFECTED SEED AND CLEAN SOIL

### EXPERIMENT I

Red cabbage seed that had produced a number of badly diseased crops in 1922 was secured and plantings made on June 2, 1923. Seedbed treatments were applied in the usual manner and lots of plants were set in the field from each plant-bed plat.

TABLE 4.—EFFECT OF SEEDBED TREATMENT ON BLACK-LEG INFECTION.

| TREATMENT | NUMBER OF PLANTS | NUMBER OF INFECTED PLANTS | PERCENTAGE OF INFECTED PLANTS |
|---|---|---|---|
| Check, none | 163 | 41 | 24.5 |
| Mercuric chloride, 1 to 1,000, applied 3 times | 126 | 3 | 2.4 |
| Bordeaux, 4–6–50, applied 3 times | 116 | 5 | 4.3 |

The season was not favorable for the development of black-leg. Thus, in 1922, plantings from this seed stock showed 80 to 100 per cent black-leg, while the untreated checks from the same seed in 1923 showed only 24.5 per cent black-leg. Nevertheless, both the mercuric chloride treatment and the bordeaux mixture greatly reduced the amount of the disease as indicated in Table 4. An undesirable feature was the very severe plant injury that resulted from applications of mercuric chloride. This injury consisted first of leaf burning and later in retarded growth and reduced stand. That the treatments weakened the plants that survived and were transplanted was

indicated by the fact that many died after transplanting, and even after extensive resetting the stand secured in the mercuric chloride plat was poor as compared with other plats.

EXPERIMENT II

Diseased red and green cabbage seed was sown on June 3, and on June 20 the plants, then showing their first true leaf, were ready for the first seedbed treatment. A succession of rains kept the ground soaked for several days, however, so that it was not until June 23 that the application could be made. A second treatment was given on June 30. Dry weather prevailed from June 30 until the time the plants were set in the field and consequently a third treatment was not given. The solutions used in this experiment were mercuric chloride 1 to 1,500 for the first treatment and 1 to 1,200 for the second. Semesan and formalin were used at 1 to 500 for both treatments. Black-leg made a rather conspicuous development this year in the plant-bed so that it was possible to make counts of leaf and stem lesions. These data are given in Table 5.

TABLE 5.—EFFECT OF VARIOUS TREATMENTS ON BLACK-LEG INFECTION.

| TREATMENT | SEED LOTS | NUMBER OF LEAF LESIONS FROM BLACK-LEG | NUMBER OF STEM LESIONS FROM BLACK-LEG |
|---|---|---|---|
| Mercuric chloride, 2 times | 12, 13, and 14 | 24 | 14 |
| Semesan, 2 times | 12, 13, and 14 | 10 | 10 |
| Formalin, 2 times | 12, 13, and 14 | 35 | 39 |
| Untreated check | 12, 13, and 14 | 44 | 51 |

TABLE 6.—EFFECT OF SEEDBED TREATMENT ON BLACK-LEG INFECTION IN THE FIELD.

| TREATMENT | SEED LOTS | NUMBER OF PLANTS SET | NUMBER OF OF HEALTHY PLANTS NOV. 15 | PERCENTAGE OF HEALTHY PLANTS NOV. 15 | AVERAGE PERCENTAGE OF HEALTHY PLANTS |
|---|---|---|---|---|---|
| Mercuric chloride, 2 times | 13 | 54 | 17 | 32.6 | |
| | 14 | 31 | 0 | 0.0 | 16.30 |
| Semesan, 2 times | 13 | 69 | 36 | 52.2 | |
| | 14 | 44 | 7 | 15.9 | 34.05 |
| Formalin, 2 times | 13 | 64 | 21 | 32.8 | |
| | 14 | 57 | 1 | 1.7 | 17.25 |
| Untreated check | 13 | 94 | 21 | 22.3 | |
| | 13 | 68 | 21 | 30.8 | |
| | 14 | 123 | 9 | 7.3 | |
| | 14 | 48 | 2 | 4.1 | 16.10 |

Lots of plants from each plat were set in the field and the data given in Table 6 show the results on November 15.

The data given in Tables 5 and 6 show that, altho the corrosive sublimate reduced the amount of infection as indicated by the figures in Table 5, this reduction was not sufficient to reduce the loss from the disease in the field as shown by the figures in Table 6. Thus, in the field the percentage of plants killed was equally high in corrosive sublimate-treated and check plats. Semesan alone gave partial control. The inefficiency of the seedbed treatments in 1924 was entirely expected, since, as has been mentioned, a rainy period was encountered just at the time the first treatment should have been applied. Fully matured fruiting bodies of the fungus causing black-leg were discovered only a week after the first seedbed application so there is no question but that the disease had spread before the applications

TABLE 7.—EFFECT OF VARIOUS SEEDBED TREATMENTS ON BLACK-LEG INFECTION IN BRUSSELS SPROUTS.

| ROW NO. | TREATMENT | NUMBER OF LIVING PLANTS | NUMBER OF PLANTS KILLED BY BLACK-LEG | NUMBER OF LVIING PLANTS WITH PHOMA LEAF LESIONS | TOTAL BLACK-LEG INFECTION | |
|---|---|---|---|---|---|---|
| | | | | | Number | Per cent |
| 51 | Check | 172 | 2 | 4 | 6 | 3.4 |
| 52 | | 177 | 2 | 15 | 17 | 9.6 |
| 53 | | 186 | 1 | 0 | 1 | 0.5 |
| 54 | | 189 | 1 | 0 | 0 | 0.0 |
| 55 | | 182 | 2 | 2 | 3 | 2.7 |
| | Average of checks | 181.2 | | | | 3.24 |
| 58 | Mercuric chloride | 200 | 0 | 0 | 0 | |
| 59 | | 182 | 0 | 0 | 0 | |
| 60 | | 195 | 0 | 1 | 1 | 0.5 |
| | Average for mercuric chloride | 192.3 | | | | 0.17 |
| 63 | Semesan | 182 | 2 | 2 | 4 | 2.2 |
| 64 | | 185 | 1 | 2 | 3 | 1.6 |
| 65 | | 185 | 0 | 0 | 0 | 0.0 |
| | Average for Semesan | 184 | | | | 1.27 |
| 68 | Formalin | 163 | 8 | 11 | 19 | 11.6 |
| 69 | | 167 | 3 | 6 | 9 | 5.5 |
| 70 | | 188 | 1 | 8 | 9 | 4.7 |
| | Average for formalin | 172.6 | | | | 7.26 |

were made. These results indicate that the seedbed treatments are effective only if applied in time to prevent the early spread of this disease.

EXPERIMENT III

In a large brussels sprouts bed located at East Marion, plats were staked out in the spring of 1924. The sprout seed proved to be slightly black-leg infected. Each plat was given three treatments. Semesan and formalin were used 1 to 600 for the first applications and 1 to 500 for the second and third applications. Mercuric chloride was used 1 to 1,800 for the first application, 1 to 1,500 for the second, and 1 to 1,200 for the third. At the end of the growing season the data in Table 7 were taken, showing the incidence of disease in the plats receiving the various treatments.

No unseasonable rains were encountered and conditions were very favorable for securing optimum results from the seedbed treatments. It will be seen from the figures given in Table 7 that mercuric chloride gave almost perfect control of black-leg, while the results with Semesan and formalin were not favorable. Also, it is interesting to note that brussels sprouts treated in this experiment were in no way injured by the applications.

EXPERIMENT IV

Infected seed was sown on May 28, 1925. Mercuric chloride solutions were applied 1 to 1,800 for the first application and 1 to

TABLE 8.—EFFECT OF VARIOUS SEEDBED AND SEED TREATMENTS ON BLACK-LEG INFECTION.

| TREATMENT | NUMBER OF INFECTED PLANTS | NUMBER OF HEALTHY PLANTS | PERCENTAGE OF HEALTHY PLANTS |
|---|---|---|---|
| Mercuric chloride seedbed treatment | 8 | 32 | 80 |
| Semesan seedbed treatment | 15 | 25 | 62.5 |
| Seed soaked 30 minutes in 0.1 per cent mercuric chloride | 10 | 30 | 75 |
| Seed soaked 2 hours in 0.25 per cent Semesan | 30 | 10 | 25 |
| Seed soaked 25 minutes in water at 50°C. | 1 | 39 | 97.5 |
| Untreated check | 18<br>19 | 20<br>21 | 45.0<br>52.5 |

1,500 for the second treatment. Semesan was used 1 to 400 for both applications. The results are given in Table 8.

With the black-leg infection present in the seed the seedbed treatments with mercuric chloride again gave a marked reduction in the amount of disease. Treatments with Semesan were not so effective. Seed treatment, however, is recommended for black-leg infected seed and so figures giving the results from seed treatment of the same lot of diseased seed, planted at the same time, are included in Table 8. These figures show that an effective seed treatment, such as the hot water method, gives by far the best results. It is of interest to note, however, that the two chemicals in this experiment gave better control of the seed-borne black-leg infection when used for treating the plants in the beds than they did when used as seed disinfectants before sowing.

## TESTS WITH HEALTHY SEED AND INFECTED SOIL

The fact that seedbed treatments may give excellent control of black-leg when the infection is seed-borne is interesting but not extremely important, since this phase of the disease can be more economically and certainly cared for by actual treatment of the seed. Consideration is now given to the efficiency of the seedbed treatments against black-leg when the infection is present in the soil.

### EXPERIMENT V

Healthy cabbage and cauliflower seed were sown in diseased soil. Mercuric chloride was applied at dilutions of 1 to 1,800, 1 to 1,500, and 1 to 1,200, using the weakest solution first and the strongest last.

TABLE 9.—AMOUNT OF BLACK-LEG INFECTION FOLLOWING VARIOUS TREATMENTS APPLIED TO INFECTED SOIL.

| SERIES | Untreated checks | PERCENTAGE OF BLACK-LEG INFECTION | | | | | |
|---|---|---|---|---|---|---|---|
| | | Mercuric chloride applied | | Semesan applied | | Formaldehyde applied | |
| | | Two times | Three times | Two times | Three times | Two times | Three times |
| 1 | 16.2 | 6.1 | 14.3 | 20.4 | 19.2 | 17.8 | 10.6 |
| 2 | 8.7 | 15.2 | 0.0 | 5.9 | 11.7 | 16.1 | 14.4 |
| 3 | 16.1 | 17.3 | 10.3 | 4.1 | 12.0 | 10.1 | 7.8 |
| 4 | 5.4 | 14.2 | 7.1 | 8.6 | 7.4 | 10.0 | 12.4 |
| 5 | 4.9 | 10.7 | 10.2 | 11.4 | 15.0 | 15.2 | 10.7 |
| 6 | 13.5 | 12.0 | 0.0 | 7.6 | 4.2 | 7.9 | 7.1 |
| Average | 10.8 | 12.58 | 6.98 | 9.7 | 11.7 | 12.85 | 10.5 |

Semesan and formalin, both at a dilution of 1 to 500, were used. Table 9 gives the black-leg counts in treated and untreated plats.

The figures given in Table 9 show that, while there was considerable variation in the percentage of black-leg present in different areas, none of the treatments gave satisfactory control of the disease.

### EXPERIMENT VI

Healthy seed was sown in infested soil and in this test a variety of different dilutions of mercuric chloride were tried. Each plat was given two treatments. The percentages of black-leg infection are given in Table 10.

TABLE 10.—AMOUNT OF BLACK-LEG INFECTION FOLLOWING TWO APPLICATIONS OF MERCURIC CHLORIDE TO INFESTED SOIL.

| SERIES | PERCENTAGE OF BLACK-LEG INFECTION | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mercuric chloride dilutions | | | | | | | |
| | Average for 12 check plats | 1 to 3,000 | 1 to 2,500 | 1 to 2,000 | 1 to 1,800 | 1 to 1,500 | 1 to 1,200 | 1 to 1,800 and 1 to 1,500 | 1 to 1,500 and 1 to 1,200 |
| 1 | 16.5 | 26 | 15 | 25 | 12 | 27 | 8 | 41 | 37 |
| 2 | 16.5 | 7 | 21 | 16 | 20 | 14 | 28 | 31 | 7 |
| 3 | 16.5 | 12 | 19 | 2 | 21 | 11 | 18 | 5 | 14 |
| 4 | 16.5 | 18 | 13 | 10 | 9 | 18 | 5 | 10 | 15 |
| Average | 16.5 | 15.75 | 17.0 | 13.25 | 15.5 | 17.5 | 14.75 | 21.75 | 18.25 |

In this experiment two treatments with any strength of mercuric chloride from 1 to 1,200 to 1 to 3,000 did not control black-leg.

### EXPERIMENT VII

Here the possibility of controlling black-leg derived from soil-borne infection was investigated from two new angles. First, the effect of five applications was compared with the standard treatment of two applications. Second, the mercuric chloride was compared with several other mercury disinfectants. As in the previous experiments of this series, healthy seed was sown in infested soil. Mercuric chloride was used at dilutions of 1 to 1,800, 1 to 1,500, and 1 to 1,200. The most dilute solution was used for the first application and the most concentrated for the last application. Other mercury disinfectants, including Semesan, Uspulun, Bayer Compound, and Germisan, were used at a dilution of 1 to 400. The results are given in Table 11.

TABLE 11.—AMOUNT OF BLACK-LEG INFECTION IN INFECTED SOIL FOLLOWING TREATMENT WITH VARIOUS MERCURY COMPOUNDS.

| SERIES | PERCENTAGE OF BLACK-LEG INFECTION | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Untreated checks | Mercuric chloride applied | | Semesan applied | | Uspulun applied | | Bayer Compound applied | | Germisan* applied | |
| | | Two times | Five times | Two times | Five times | Two times | Five times | Two times | Five times | Two times | Five times |
| 1 | 32.7 | 25.4 | 22.9 | 27.6 | 13.0 | 34.1 | 15.8 | 23.3 | 16.9 | 24.4 | 0.0 |
| 2 | 27.5 | 32.7 | 17.5 | 19.0 | 14.6 | 27.6 | 17.6 | 29.8 | 23.8 | 9.8 | 0.0 |
| 3 | 32.3 | 25.3 | 15.2 | — | — | — | — | — | — | — | — |
| 4 | 26.3 | 31.5 | 15.3 | — | — | — | — | — | — | — | — |
| 5 | 35.5 | 28.9 | 39.4 | — | — | — | — | — | — | — | — |
| Average | 30.86 | 28.76 | 22.06 | 23.3 | 13.8 | 30.85 | 16.7 | 26.5 | 20.35 | 17.1 | 0.0 |

*Germisan applied five times greatly reduced the stand of plants.

From the data given in Table 11 it is very evident that in no case were two applications sufficient to reduce the amount of black-leg infection. Five applications of mercuric chloride also did not appreciably reduce the percentage of infection. Five applications of Semesan and Uspulun cut the percentage of disease about in half. This degree of disease control, however, is not significant, for the amount of infection escaping would be capable of causing a maximum field loss.

It is interesting to note that in this experiment none of the materials used caused serious plant injury when but two treatments were made. Five treatments with Germisan, however, almost destroyed the plants and five treatments with mercuric chloride caused very severe injury. Five treatments with Semesan, Uspulun, or Bayer Compound did not injure the plants.

## CONCLUSIONS REGARDING BLACK-LEG CONTROL

Seedbed treatments have controlled the black-leg disease *when the infection was seed-borne*. The degree of control, however, was influenced by weather conditions. A rainy period thus greatly favored disease development and dissemination. Also, a rainy period maintained the soil in a semi-saturated condition and so was liable to prevent timely applications of the disinfectants. Seedbed treatments may be compared with spraying, and as with spraying, unless the disinfectants were applied before the disease had spread, they were without effect.

The experiments using infested seedbed soil show that even as many as five treatments will not control the black-leg disease *when the soil is the source of the infection*. In view of the excellent control of club-root, a disease that is caused entirely by soil-borne infection, this failure to control black-leg might appear peculiar. The reason seems apparent, however, for the black-leg disease spreads from plant to plant thru the air and enters the plant thru above-ground parts. Usually the spores are spattered by rain and infect the very young leaves, especially the cotyledons. The disease then grows down into the main stem of the plant. The solutions applied to the plant-bed in this work reached only a narrow band of soil along the actual plant-row. The soil between the rows was not touched and so the disease was freely spattered in from the untreated soil between the rows, and later the early-infected plants served as centers for further spread of infection, all of which occurred thru the air. Thus, in no case was this disease carried thru the soil nor did infection take place thru the root, and, consequently, disinfection of the soil around the roots was ineffective. Club-root, of course, is a disease that spreads entirely thru the soil and plants are infected only thru the roots.

It may seem strange, also, that the seedbed treatments were quite effective in controlling black-leg where the disease was carried in the seed. With the seed-borne fungus, however, all disease infection was confined to the plant-row and here it was subject to the action of the disinfectants. When the black-leg disease is seed-borne, the fungus grows with the developing seedling to the surface of the ground. There the infected seedling often dies and the fungus sporulates on the stem of the dead plant. The spores are spattered by rain to the nearby leaves of healthy plants. The experiments have indicated that treatment of the seedbed when the black-leg infection is seed-borne will control the disease if applied before the fungus has had time to reach the surface of the ground and make its primary spread.

## EXPERIMENTS WITH BLACK-ROT

Black-rot is a major disease of cauliflower on Long Island where it is commonly called blight. The infection may come from either seed or seedbed soil, just as with black-leg. The disease control efficiency of various seedbed treatments was tested by using infected seed and healthy soil and by using healthy seed and infected soil.

There is little historical basis for believing that seedbed treatment would be effective against black-rot. Ceaser (3) reported that cabbage plants treated with mercuric chloride and untreated checks were equally attacked by black-rot. His treatments, however, were made after the plants had been set in the field and not while they were in the seedbed and so could not have prevented the primary infection that occurs while the plants are in the seedbed. The writer (4) tested mercuric chloride seedbed treatments against black-rot infection carried in the seed only and obtained good control.

## TESTS WITH BLACK-ROT INFECTED SEED AND HEALTHY SOIL

### EXPERIMENT I

Brussels sprouts seed known to be infected was sown on June 2, 1923, in healthy soil. Three seedbed treatments were given and lots of plants were set in the field from treated and untreated plats. The primary systemic black-rot infection made its appearance early in September, and before secondary spread had obscured it counts of diseased plants were taken as given in Table 12.

TABLE 12.—EFFECT OF VARIOUS SEEDBED TREATMENTS ON BLACK-ROT INFECTION.

| TREATMENT | NUMBER OF PLANTS | PLANTS DEVELOPING SYSTEMATIC BLACK-ROT | |
|---|---|---|---|
| | | Number | Per cent |
| Mercuric chloride, 3 times | 37 | 0 | 0.0 |
| Bordeaux mixture, 3 times | 76 | 17 | 22.5 |
| Untreated check | 37 | 14 | 37.8 |

The data given in Table 12 show that mercuric chloride completely eliminated black-rot, but that bordeaux mixture used in the same way had very little effect.

### EXPERIMENT II

Infected cauliflower and brussels sprouts seed were sown on June 5. Treatments were given on June 23 and 30. These treatments should have been applied earlier but were delayed by rains. A third treatment also was scheduled but was not applied owing to the fact that after June 30 the weather continued dry up to the very time of setting the plants in the field. Despite these unfavorable circumstances the treatments distinctly reduced the amount of black-rot infection as will be seen by the figures given in Table 13.

TABLE 13.—EFFECT OF SEEDBED TREATMENTS ON AMOUNT OF BLACK-ROT INFECTION APPEARING IN PLANTS FROM INFECTED SEED.

| PLAT NO. | TREATMENT | NUMBER OF PLANTS | PLANTS DEVELOPING SYSTEMATIC BLACK-ROT | | AVERAGE PERCENTAGE BLACK-ROT INFECTION |
|---|---|---|---|---|---|
| | | | Number | Per cent | |
| 1 | Mercuric chloride, 1 to 1,500 and 1 to 1,200 | 31 | 1 | 3.2 | 1.6 |
| 2 | | 74 | 0 | 0.0 | |
| 3 | Semesan, 1 to 500 | 106 | 0 | 0.0 | 2.05 |
| 4 | | 73 | 3 | 4.1 | |
| 5 | Formalin, 1 to 500 | 102 | 1 | 0.9 | |
| 6 | | 77 | 0 | 0.0 | 0.45 |
| 7 | Check | 90 | 2 | 2.2 | |
| 8 | | 96 | 4 | 4.1 | |
| 9 | | 75 | 3 | 4.0 | |
| 10 | | 85 | 9 | 10.5 | 5.2 |

The results of this experiment show that, while seedbed treatment distinctly reduced the amount of infection, it should not be depended upon to give complete control, and that black-rot or blight must be completely controlled in the plant-bed to secure satisfactory results in the field as the disease will spread rapidly from any small beginning. Seed treatment, on the other hand, can be made 100 per cent effective and hence is certainly to be preferred for combating a seed-borne black-rot infection.

## TESTS WITH CLEAN SEED AND BLACK-ROT INFECTED SOIL

In 1924, and again in 1925, lots of seed known to be free from disease were sown in soil into which had been worked the remains of black-rot diseased plants. Seedbed treatments were given following the usual procedure. Mercuric chloride solutions of various strengths and various numbers of applications were tried. Formalin, Semesan, Uspulun, Germisan, and Bayer Compound were also used. The results were always negative. Whenever the black-rot infection was present in the plant-bed soil, leaf lesions characteristic of this disease became apparent during the latter part of the plant-bed period and none of the seedbed treatments had any visible effect in preventing the appearance of this disease infection. Similar negative results were secured in each of three separate experiments. The ineffectiveness of seedbed treatments with soil-borne black-rot infection is quite in line with the results secured in the black-leg experiments,

for black-rot is also spread by rain spattering and so easily reaches the leaves from the untreated soil between the rows.

It has been proved that seed may be sown in diseased soil and infection of the leaves may be prevented entirely by sterilizing all of the soil and not merely a narrow band along the plant row. Thus, in 1924, two blocks each 20 x 40 feet were laid out in a field that grew a badly diseased crop of cauliflower the previous year. One plat was thoroly soaked with formaldehyde solution 1 to 50, while the other was left untouched. Seed grown in the greenhouse and known to be free from disease was sown in each of these plats. The plants were kept under careful observation and in due time black-rot lesions appeared on the leaves of numerous plants all of which were located in the untreated plat. Not a single infection was observed on the plants grown in the formalin-sterilized plat.

## EXPERIMENTS WITH DAMPING-OFF

On Long Island damping-off is commonly caused by the fungus *Rhizoctonia solani* Kühn. This fungus is extremely abundant and occurs in virgin soils. The damping-off disease, however, is not a serious problem in cabbage, cauliflower, and brussels sprouts plant-beds, probably because these beds are sown in the late spring when conditions generally are not especially favorable for the disease. Nevertheless, it is very common to find whole beds of plants with the stems below the soil surface coated with the black fungus mat characteristic of Rhizoctonia attack. Not infrequently a good many plants are killed and still others develop the characteristic wiry stems. Rhizoctonia is present not only on the stems of the plants of the beds, but it is very prevalent on the plants after they are set in the field.

Gloyer and Glasgow (6) first called attention to the effectiveness of mercuric chloride treatment of plants in the seedbed in controlling damping-off. Subesequently, Rosen (11) called attention to the value of Uspulun in combating this disease. Also, in the popular literature notes have appeared which tell of successful control of damping-off by seedbed treatment. Our own experiments were begun during the winter of 1923.

### EXPERIMENT I

Decaying cauliflower roots and field soil were brought into the greenhouse and made into a seedbed. The seed was sown and when

the plants were showing the first true leaf a treatment was applied. A second treatment was given 11 days later. The weather conditions in the greenhouse favored the disease and it made rapid development. There was no evidence of any difference between treated and untreated plats, however, for all were heavily infected. The only positive result secured in this experiment was some information as to the toxicity to the plants of different disinfecting materials. Without going into details, it was found that Semesan 1 to 400 was distinctly less toxic than mercuric chloride even so dilute as 1 to 1,800. The mercuric chloride, on the other hand, was less destructive than mercuric iodide, while mercuric cyanide was highly toxic even in dilutions as high as 1 to 3,000. The failure to obtain control of damping-off in this experiment was thought likely to be due to the favorable conditions for disease development. The work was continued in the field the next spring.

EXPERIMENT II

Plats were laid out in a brussels sprouts plant-bed and the treatments applied in the usual manner. Mercuric chloride was used 1 to 1,800, 1 to 1,500, and 1 to 1,200. Semesan and formalin were used 1 to 500. The applications were well timed and conditions were very favorable for optimum results. Damping-off made its appearance during the latter part of the plant-bed period and destroyed quite a few plants. Careful examination showed equally as many diseased plants in treated plats as there were in the checks. A later examination was made at the time the plants were being pulled for transplanting, and altho there was abundant evidence of Rhizoctonia

TABLE 14.—AMOUNT OF LOSS FROM DAMPING-OFF FOLLOWING VARIOUS SEEDBED TREATMENTS.

| SERIES | PERCENTAGE OF LOSS FROM DAMPING-OFF | | | | | | |
|---|---|---|---|---|---|---|---|
| | Untreated checks | Mercuric chloride applied | | Semesan applied | | Formalin applied | |
| | | Two times | Three times | Two times | Three times | Two times | Three times |
| 1 | 8.9 | 11.0 | 0.0 | 11.5 | 14.4 | 10.7 | 0.0 |
| 2 | 3.2 | 8.3 | 0.0 | 5.9 | 0.0 | 6.4 | 2.4 |
| 3 | 6.8 | 10.3 | 1.4 | 5.5 | 7.2 | 2.9 | 6.5 |
| 4 | 4.7 | 0.0 | 0.0 | 5.0 | 0.0 | 3.3 | 0.0 |
| 5 | 10.5 | 0.0 | 0.0 | 7.6 | 0.0 | 0.0 | 0.0 |
| 6 | 8.8 | 12.1 | 1.4 | 5.7 | 2.8 | 2.7 | 5.4 |
| Average | 7.15 | 6.95 | 0.5 | 6.87 | 4.1 | 4.3 | 2.4 |

on the stems, plants from treated and untreated plats showed an equally heavy infection.

EXPERIMENT III

In still another test conducted during the spring of 1924 somewhat more encouraging results were secured. In this experiment two and three applications of mercuric chloride at dilutions of 1 to 1,800, 1 to 1,500, and 1 to 1,200 were compared with similar treatments using Semesan and formalin 1 to 500. The results are given in Table 14.

Tho the percentage of diseased plants was very low, mercuric chloride applied three times gave distinct control, but neither of the other materials was effective at the concentrations employed. In this experiment two applications of mercuric chloride failed to control the disease, and this is unfortunate since very rarely are plants in the beds given more than two applications for maggots. Consequently, a special effort was made to determine whether two applications of any strength of mercuric chloride would prove effective against the damping-off disease.

EXPERIMENT IV

Mercuric chloride was used in strengths varying from 1 to 1,200 to 1 to 3,000 and two applications were made. The soil used for this experiment was heavily infested with Rhizoctonia and the plants pulled were heavily infected. Treated and untreated plats showed no difference in the amount of infection, neither did strong concentrations of mercuric chloride give better results than the weak.

EXPERIMENT V

This test was conducted in the spring of 1925 and two applications of mercuric chloride at dilutions of 1 to 1,800 and 1 to 1,500 were compared with Semesan, Uspulun, Bayer Compound, and Germisan, all applied twice at dilutions of 1 to 400. Also, mercuric chloride, five applications, 1 to 1,800, 1 to 1,500, and 1 to 1,200, using the weakest solutions first, was compared with the same four compounds applied five times at 1 to 400 strengths. The plat of ground on which this experiment was conducted had been sown to cruciferous crops for the two years previous and was heavily infested with Rhizoctonia.

The average percentage of infection in 10 check plats containing a total of 902 plants was 24.5 per cent, and not a single treatment gave a significant reduction in the percentage of infection. This result was secured in spite of the fact that mercuric chloride and

Germisan applied five times severely injured the brussels sprouts plants used in this experiment.

It has been pointed out that others have secured control of damping-off by means of seedbed treatments, yet in these experiments negative results were consistently secured. Various reasons may be assigned to explain these differences, but one that appears quite likely has to do with the timing of the applications. As previously noted it is customary on Long Island not to give the first application till the plants have been up two weeks and this was the procedure followed. Gloyer and Glasgow (6), however, made their first application as soon as the plants were well out of the ground, and in view of the results here reported it would appear that these very early applications are essential for the control of damping-off.

The reason for not making very early applications is, of course, the greatly increased possibility of serious injury from the treatments, a matter that is especially important with sensitive crops such as cauliflower and brussels sprouts.

That it is quite possible to prevent Rhizoctonia infection by soil disinfection was clearly shown in 1923. That summer large seedbed plats on three farms were disinfected by saturating with a 1 to 50 solution of formaldehyde. The plants grown in these plats were 95 to 98 per cent clean, while in adjacent check plats the percentage of clean plants varied from 40 to 75. Plants from these plats were planted separately in the fields and observed during the summer. The treated soil plants grew more vigorously so that by mid-season the difference was distinct. However, the plants coming from the untreated soil began to head first in each field, and by the time frost put an end to the season the untreated plants had in all tests outyielded the treated. The result in brief, therefore, was that elimination of Rhizoctonia in the plant-bed increased the vegetative growth of the plants but delayed heading, and because of this last, reduced the yield.

## PLANT INJURY CAUSED BY SEEDBED TREATMENTS

It has been generally recognized that mercuric chloride is more or less toxic toward plants, and Glasgow (5) has pointed out the marked differences in susceptibility to injury of different crucifers. In these experiments cabbage, cauliflower, and brussels sprouts have all been used as plant material because Long Island farmers grow large acre-

ages of all three. Dilutions of mercuric chloride of 1 to 1,800 and 1 to 1,500 have generally been employed in this work, tho the usual recommendation for maggot control has been 1 to 1,200 or 1 to 1,500. These dilute solutions gave good maggot control, but even with these more dilute applications all of the different cruciferous crops have suffered injury. This injury has sometimes been very serious, at other times it was of little or no consequence. Of the three crucifers used, the brussels sprout has proved by far the most sensitive to injury with cabbage the most resistant and cauliflower intermediate between the two. Young seedlings were much more easily injured than larger plants. Plants given few applications suffered less than plants given frequent applications. Thus, in one experiment, 10 plats treated with mercuric chloride two times averaged 99.5 plants each, while 10 plats treated with mercuric chloride five time averaged 69.4 plants each. Ten untreated plats averaged 90.2 plants each.

When very severe, injury from seedbed treatment was evidenced by a marked reduction in the stand of plants; when not so severe, merely by a burning of the leaves accompanied by a more or less marked check in growth. It has been quite evident during the course

TABLE 15.—RELATIVE TOXICITY OF VARIOUS MERCURY DISINFECTANTS TOWARD BRUSSELS SPROUTS.

| MATERIAL | NUMBER OF APPLICATIONS | NUMBER OF PLATS PULLED | TOTAL NUMBER OF PLANTS PULLED | AVERAGE NUMBER OF PLANTS PER PLAT | AMOUNT OF INJURY |
|---|---|---|---|---|---|
| Mercuric chloride, 0.055 to 0.083 per cent | 2 | 10 | 995 | 99.5 | Temporary, recovery complete |
| | 5 | 10 | 694 | 69.4 | Marked and severe |
| Checks | | 10 | 902 | 90.2 | None |
| Semesan, 0.25 per cent | 2 | 2 | 240 | 120.0 | None |
| | 5 | 2 | 215 | 107.5 | None |
| Uspulun, 0.25 per cent | 2 | 2 | 175 | 87.5 | None |
| | 5 | 2 | 238 | 119.0 | None |
| Bayer Compound, 0.25 per cent | 2 | 2 | 244 | 122.0 | None |
| | 5 | 2 | 210 | 105.0 | Temporary, recovery complete |
| Germisan, 0.25 per cent | 2 | 2 | 245 | 122.5 | Temporary, recovery complete |
| | 5 | 2 | 23 | 11.5 | Very severe |

of these experiments that varying weather conditions were a major factor in determining the amount of injury resulting from treatments. Exactly what soil and air moisture and temperature conditions favor plant injury have not been determined, but when weather conditions at the time of applying the treatments, and for the week or ten days after, were dry and hot, disaster was especially likely to come. The chances of injury from mercuric chloride treatment are serious enough to justify a consideration of possible ways to avoid the trouble. One excellent plan would be to substitute a material for the mercuric chloride that is less toxic to the plants. Table 15 gives an idea of the comparative toxicity of several mercury disinfectants.

From the counts in Table 15 it may be seen that five applications of Germisan destroyed all but a few of the plants, and since this material gave little if any better disease control than Uspulun, which proved to be one of the safest materials used, the latter is certainly to be preferred. Bayer Compound has given good results but has not been extensively tested as yet. Semesan, a compound similar to Uspulun, for some reason has often failed to give quite as good disease control as the latter. However, it is a very safe material and would probably give better results if employed in higher concentrations.

Thus, in so far as disease control is concerned, an effective organic mercury disinfectant could be advantageously substituted for mercuric chloride; but since the primary purpose of seedbed treatment is maggot control and since the disease control secured is generally a secondary consideration, this substitution becomes impracticable in most cases for the organic mercury disinfectants are much less effective against the cabbage maggot than mercuric chloride.

## DISCUSSION OF RESULTS

Of the four diseases considered in this report, black-leg, black-rot, and club-root are the more important, and infection from all three may survive the winter in the soil. Two of these troubles, black-leg and black-rot, readily infect the seed and so pass from one year's crop to the next. Seed infection, however, can be economically and effectively destroyed be means of hot-water seed treatment. Soil infection is not so readily guarded against, tho by careful rotation of the seedbed area this danger may be reduced to a minimum. Soil sterilization is very effective but too laborious to be practicable on more than small areas.

Seedbed treatment by the mercuric chloride method is not difficult, however, and in beginning this work it was hoped that the maggot treatment would prove to be an easy and economical substitute for complete soil sterilization.

The results obtained clearly show that the treatments possessed marked fungicidal properties. In the club-root experiments the treated plats generally had a minimum of infected plants as compared to moderate, and in some cases, heavy infection in the checks left untreated. In the black-leg and black-rot experiments the treatments gave good disease control only when the source of the infection was the seed and not when the disease infection was in the seedbed soil. Obviously in this latter case the infection was able to reach the plants from the untreated soil between the rows. This is not surprising in view of the fact that both diseases are readily disseminated by rain spattering and enter the plants by way of the leaves.

These negative results indicate that nothing short of disinfecting the entire soil surface could be expected to control black-leg or black-rot when the infection is present in the soil. While this would be impracticable with field plant-beds, it would appear quite possible where plants are grown in cold frames in closely spaced rows. In any case, the value of the mercuric chloride seedbed treatment, both as a control measure for cabbage maggot and as an aid in controlling diseases in the seedbed, appears established beyond reasonable doubt.

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